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SUITABILITY OF CONSERVATION TILLAGE SYSTEMS TO ONTARIO SOIL TYPES

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During the last decade many Ontario farmers have successfully adopted conservation tillage systems on a wide variety of soil types. The purpose of this Factsheet is to highlight the suitability of various conservation systems to different soil types and to outline the key principles required for their successful adaptation.

The primary objective of conservation tillage is to leave residue on the soil surface for protection from water and wind erosion while maintaining crop yields. Ontario erosion research (3) shows that the soil must be covered by at least 20% residue after planting for effective protection against soil erosion.

Soils differ dramatically in their response to conservation tillage and in their susceptibility to soil erosion. Soils which are well drained due to soil texture or sloping land have performed very well with conservation tillage. This is primarily due to the ability of the soil to dry and warm quickly under crop residue. Many of these soils are also often the most susceptible to erosion. Poorly drained soils found in depressional areas seldom present major erosion problems. These soils are difficult to manage in any tillage system.

TILLAGE SUITABILITY RATING SYSTEM

The suitability rating system (Table 1) summarizes the accumulated knowledge of farmers and extension workers of the success of conservation tillage systems on Ontario soil types.

In Table 1, tillage systems were ranked on a scale of 1 (very suitable) to 5 (not recommended). The ratings combine yield potential, the need for erosion control and the relative ease of management of the system as follows:

(1) Very suitable - High yield potential, excellent erosion protection (if required), very few problems.
(2) Well suited - Equal or better yield potential, less erosion protection, good management will overcome problems.

Table 1. Suitability of tillage-planting systems for corn, soybeans and cereals on general Ontario soil types

SURFACE TEXTURE CLASS	DRAINAGE	YIELD POTENTIAL		EROSION POTENTIAL		POTENTIAL SOIL PROBLEMS	SUITABILITY RATING					
							Conventional		Minimum Till		No-till	
		Min.-till	No-till	Water	Wind		Fall	Spring	Fall	Spring	Fall Crops	Spring Crops
Coarse (sandy)	Well			S	S	Droughty	5	4	3	2	1	1
	Imperfect	E	I	H	S		4	3	2	1	1	1
	Poor			M	M	Wet	4	3	3	2	1	3
Medium (Loamy)	Well			S	H	Crusting	3	3	2	1	1	2+
	Imperfect	E	E	H	M	Crusting	3	3	2	2	1	2+
	Poor			M	L	Wet	1	2	2	3	2	4
Fine (Clay loam)	Well			H	M		3	3	1	2	1	3+
	Imperfect	E	D	M	L	Compaction	2	3	3	3	2	4+
	Poor			L	L	Compaction, Wet	2	2	3	4	3	4
Very Fine (Clay)	Well			M	M	Structure	2	3	3	4	1	4+
	Imperfect	D	D	L	L	Compaction	2	4	4	4	2	4+
	Poor			L	L	Compaction, Wet	3	4	4	4	3	5

YIELD POTENTIAL
As compared to fall moldboard (from Aspinall et al., 1988)
I - Increase
E - Equal
D - Decrease

EROSION POTENTIAL
S - Severe
H - High
M - Medium
L - Low

SUITABILITY RATING
1 - Very suitable
2 - Well suited
3 - Moderately suited
4 - Not well suited
5 - Not recommended

\+ Zone tillage will upgrade rating

(3) Moderately well suited - Equal yield potential, less than adequate erosion control, some management problems.
(4) Not well suited - Decreased yield potential, little erosion protection (where required), more difficult to manage.
(5) Not recommended - Serious limitations with respect to yield, or inadequate erosion protection, or management problems.

Four soil texture groups were defined on the basis of surface texture as outlined below. Subsoil properties were not used in this rating system.

(I)	Coarse	Sands, loamy sands, sandy loams	> 50 % sand and < 20 % clay
(II)	Medium	Loams, silt loams	< 50 % sand and < 27 % clay
(III)	Fine	Silty clay loam, clay loam	< 40 % sand and 27-40 % clay
(IV)	Very Fine	Silty clay, clay	> 40 % clay

Each soil texture group was further subdivided by the natural soil drainage into three subgroups: (i) Well (little excess water normally in soil); (ii) Imperfect (soil is wet for a significant portion of the growing season); and (iii) Poor (excess water evident in soil for large part of the time). These drainage classes are also applicable to artificially drained soils. Examples of soil series associated by drainage and textural groups are listed in Table 2.

YIELD POTENTIAL

Yield potential ratings were based on several years of yield information collected from side by side comparisons of conservation and conventionally tilled corn, soybean and cereal crops on various soil types in Ontario (Table 3). These ratings are weather dependent and should improve with time as farmers continue to gain experience with conservation tillage cropping systems.

Table 3. Yield indexes for all crops, 1986-1989.

TEXTURE GROUP	PAIRED TILLAGE COMPARISONS	
	Conventional vs Minimum	Conventional vs No-till
Coarse (Sand)	103	105
Medium (Loam)	103	97
Fine (Clay loam)	97	85
Very Fine (Clay)	89	84

**From J.D. Aspinall et al. T2000 1989 Progress Report.*

Conventional tillage refers to fall moldboard plowing and generally one or two passes with a cultivator or disc. Minimum tillage refers to reducing the number and intensity of tillage passes while maintaining at least 20 % of the soil surface covered with residue after planting. No-till refers to planting directly into previously undisturbed residue, with or without tillage coulters on the planter or

Table 2. Examples of associated soil series according to soil texture and drainage.

TEXTURAL CLASS	MAJOR SURFACE TEXTURE	WELL DRAINED	IMPERFECTLY DRAINED	POORLY DRAINED
		SOUTHWESTERN ONTARIO		
Coarse	Sandy	Fox	Brady	Granby
Medium	Loam	Guelph	London	Parkhill
	Silt loam	Honeywood	Embro	Crombie
Fine	Clay loam	Huron	Perth	Brookston
Very Fine	Clay	Smithville	Haldimand	Lincoln
		CENTRAL ONTARIO		
Coarse	Sandy	Tioga	Alliston	Granby
Medium	Loam	Bondhead	Guerin	Lyons
	Silt loam	Newburgh	Piccadilly	Hinchinbrooke
Fine	Clay loam	Schomberg	Smithfield	Simcoe
Very Fine	Clay	Waupoos	Solmesville	Lindsay
		EASTERN ONTARIO		
Coarse	Sandy	Uplands	Rubicon	Granby
Medium	Loam	Grenville	Matilda	Lyons
	Silt loam	----	Castor	Bainsville
Fine	Clay loam	Gananoque	Landsdowne	Napanee
Very Fine	Clay	----	Wendover	Bearbrook

drill. Ridge-till planting techniques were also included in the no-till group.

For the suitability rating in Table 1, conservation tillage systems which resulted in yield increases (or decreases) over conventional tillage on a particular soil type were assigned a higher (or lower) rating, respectively.

SOIL EROSION POTENTIAL

A soil's susceptibility to erosion is largely influenced by the length and degree of its slope, amounts of sand, silt and clay, and the amount of protective cover (1). It is generally accepted that the steeper and longer a slope, the greater the potential for soil erosion.

Fine sand sized soil particles and aggregates found in the coarse textural group are susceptible to erosion by both wind and water on most slopes. The well drained, medium-textured soils are very susceptible to erosion by water. Those located on steeper, rolling slope positions are most susceptible. Soils in the fine and very fine textural groups are not generally susceptible to soil erosion, unless they are well drained and found on rolling to undulating slopes. Imperfectly and poorly drained soils are usually located in lower level or depressional landscapes, and as such, seldom present major erosion problems. Heavy clay soils are typically found in level landscape positions and are considered to have low potential to erode.

In Table 1, tillage systems which offered the most protective cover to erodible soils (while increasing yield potential from conservation tillage) were assigned the highest ratings. If yield potentials were about equal (within 5 %) the systems offering greater amounts of protective residue were rated higher.

POTENTIAL SOIL PROBLEMS

Natural soil characteristics will influence the management of any tillage system and must be considered in suitability ratings. By circumventing some soil problems, the likelihood of success of conservation tillage systems will increase, such as when tiles are used to improve naturally poor internal drainage.

In some cases, conservation tillage itself can circumvent soil problems, such as when moisture retaining residue improves the limitations of droughty soils. As well, a soil which is susceptible to compaction may benefit from reduced traffic and reduced potential to compact soil in no-till (although timing of traffic must still be carefully considered). Crusting problems are decreased where crop residues protect soils from the forces of rainfall. Stoniness problems may also be reduced with no-till since fewer stones are pulled up to the soil surface.

Management practices other than conservation tillage may also improve erosion control. For example, slope lengths can be shortened by strip cropping or terracing, decreasing the severity of erosion due to long slopes.

Potential soil problems which are important with respect to erosion control and yield potential are listed with the associated soil type in the suitability table.

CONSERVATION TILLAGE ON GENERAL SOIL TYPES

Crop management practices may need to change when dealing with increased amounts of residue. Crop rotation is an important management strategy which increases yields, reduces the accumulation of heavy residue and provides a break in possible disease or insect cycles. Residue removal from a 15-20 cm (6-8 inch) strip in the row area will aid the drying and warming of soil in the spring and can increase yields by 5 % or more (3). Start with adequate fertility and clean fields. It may also be necessary to change herbicide and fertilization strategies. If there are compaction problems, resolve them before beginning a no-till system.

Soil structure, internal drainage, experience of the operator, and in some cases, weed control all improve with time in conservation tillage systems. Patience and commitment are required to achieve the successes realized by experienced conservation farmers.

Coarse-textured soils

Sandy and sandy loam soils require protection due to their susceptibility to erosion both by water and especially by wind. These well drained soils dry and warm quickly in the spring. Planting delays and penetration problems are not likely to be experienced.

As compared to conventional till, yield advantages seen in both minimum till and especially no-till are likely due to the moisture retaining properties of residue on these droughty soils. Systems leaving the most protective residue also offer the highest yield potential and were rated accordingly in Table 1.

Minimum tillage is easily adapted with minimal equipment modification to both the well and imperfectly drained soils. Poorly drained soils may require tiling.

Medium-textured soils

Minimum tillage offers increased yields and protection over conventional tillage on loamy soils, and as such, was rated highest. Tillage is best performed in spring on these well to imperfectly drained soils as fall tillage can allow overwinter settling. Intensive secondary tillage may lead to crusting problems.

No-till and conventional tillage have yielded about equally on these soils. As the former offers protective residue cover it was rated higher in the suitability table. For no-till systems, planting delays may be experienced and tillage coulters may be required for seedbed preparation. Extra weight may be necessary to penetrate the finer textured loams.

On the imperfectly to poorly drained soils, chisel plowing in the fall should be considered to minimize planting delays in the spring. Soil must be dry at depth of tillage to allow necessary shattering.

Fine-textured soils

Conservation tillage may be suitable only on the well drained types of these clay loam soils. Yields equal to those obtained by conventional tillage have been met using minimum tillage, and as such, received a higher rating in Table 1 due to improved protection offered by residue.

As these soils are warm and dry in the late summer, no-till winter wheat and rye have been very successful on these soils. No-till planters or drills will likely require tillage coulters for seedbed preparation. Extra weight will likely be required for penetration of coulters and nitrogen applicators. Fine-textured soils benefit from the removal of heavy residue from the planting row, which allows increased warming and drying of soil in the planting zone.

On the imperfectly and poorly drained soils of this group, fall tillage (conventional or minimum) may be required to enhance drainage and allow frost penetration to breakdown soil clods.

Rotation to a deep rooted crop is important to maintain good soil structure on these soils.

Very fine-textured soils

It is very important to stay off of these soils when conditions are wet. Maintaining good soil structure by rotating to deep, fibrous rooted crops is essential to the successful management of these soils. Tiles to improve naturally poor internal drainage are important for all tillage systems on these soils.

As with clay loam soils, these soils are warm and dry in the late summer and no-till winter wheat and rye establishments have been very successful at this time.

As planting will be delayed if spring is wet and cold, fall tillage is suitable for these soils. Adequate residue cover may be achieved by narrowing moldboard bottoms, or by chisel plowing. Yield reductions will occur if tillage is done when conditions are too wet.

REFERENCES

(1) Arnold, J. B., G. Wall, N. Moore, C.S. Baldwin, I.J. Shelton. 1987. *Soil Erosion - Causes and Effects* Ontario Ministry of Agriculture and Food. Agdex 572. Guelph, Ontario.

(2) Aspinall, J.D., R.G. Kachanoski and H.C. Lang (Eds.). 1989. *Tillage 2000 Soil Conservation 1989 Progress Report*. Ontario Ministry Agriculture and Food. Guelph, Ontario.

(3) Ketcheson, J.W., T.J. Vyn and T.B. Daynard. 1983. *Tillage Practices for Residue Management and Erosion Control*. Ontario Ministry of Agriculture and Food. Agdex 100/516. Guelph, Ontario.

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